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EARTH'S RADIATION BELTS IN THE 180 - 250 KM ALTITUDE RANGE

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EARTH'S RADIATION BELTS IN THE 180 - 250 KM ALTITUDE RANGE

(Radiatsionnyye poyasa Zemli na vysotakh 180 - 250 km)

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The radiometric instrumentation installed on board the second Soviet spaceship-satellite provided the possibility of studying the distribution of cosmic radiation and radiation belts at altitudes from 306 to 339 km.**

The third spaceship-satellite, launched on 1 December 1960 into an orbit with 187 km perigee and 265 km apogee, inclined at an angle of 65° to the equator plane, permitted to trace the intensity variation and geographic position of radiation belts at passing to lower altitudes.

The radiometric apparatus of the 3rd spaceship differed little from that installed aboard the 2nd space-ship satellite [1] (FEU-15 scintillation counter with a NaJ(Tl) crystal in the form of a cylinder 14 mm high and 30 mm in diameter). Data were entered every 3 minutes into a 24-hour capacity memory device.

* [To avoid duplication, parts of the text being a repetition of former papers, have been omitted]

** In reference to the contents of the present paper see NASA TT 8127, 8151, 8165, 8190, 8129

The general pattern of pick up readings aboard the 3rd spaceship is similar to that obtained in the 2nd spaceship [2]. When the spaceship passed from equatorial regions to higher latitudes, the intensity registered by the gas-discharge counter increased from 0.8 to $3.2 \text{ pulse cm}^{-2} \text{ sec}^{-1}$, and the energy liberation in the NaJ(Tl) crystal rose from 7.5 to $37 \text{ MeV cm}^{-2} \text{ sec}^{-1}$. The FEU count increased from 3 to $12 \text{ pulse cm}^{-2} \text{ sec}^{-1}$. The passing of the spaceship through portions of the radiation belts was attended by a sharp increase in the counting rate of the scintillation counter, and in a series of cases of other pickups also. Points at which the counting rates of the scintillation counter exceeded that of the cosmic background are annotated on the map (Fig.1). For comparison marked on the same map are also the points obtained during the flight of the second spaceship-satellite (circles). Conjugated points were found for certain points of the Northern and Southern hemispheres (the basic and the conjugated points are joined by dotted lines). It may be seen from Fig.1 that the zones of increased radiation, determined on both spaceships, coincide with one another. The unilateral connection of the zones of increased intensity in the Northern hemisphere with those of the Southern hemisphere (induced by the same geomagnetic lines of force) is evidence of the fact that these zones belong to the outer radiation belt.

The only exception is the region in the South Atlantic, which will be the object of separate consideration.

For a more detailed analysis, we superimposed in Fig.2 the scintillation counter readings obtained by means of radiometric instrumentation aboard the 2nd and 3rd spaceships-satellites along analogous portions of the trajectory. The temporal scale for the curve II is interrupted in a series of spots to compensate for the "difference in the course" taking place on account of the unequal revolution periods of the 2nd and 3rd spaceships-satellites. The letters *Ю* and C indicate the portions of the graphs correspondingly related to the southern and Northern hemispheres. As may be seen from Fig. 2, a rather good correspondence is observed in the position and intensity of count maxima on the curves I and II. This is also evidence that the position of the outer radiation belt underwent no substantial variations between the flights of the 2nd and 3rd spaceships-satellites. These considerations may be illustrated by Figures 3 and 4, where we indicated the geographic distribution of radiation intensity registered by the scintillation counter.

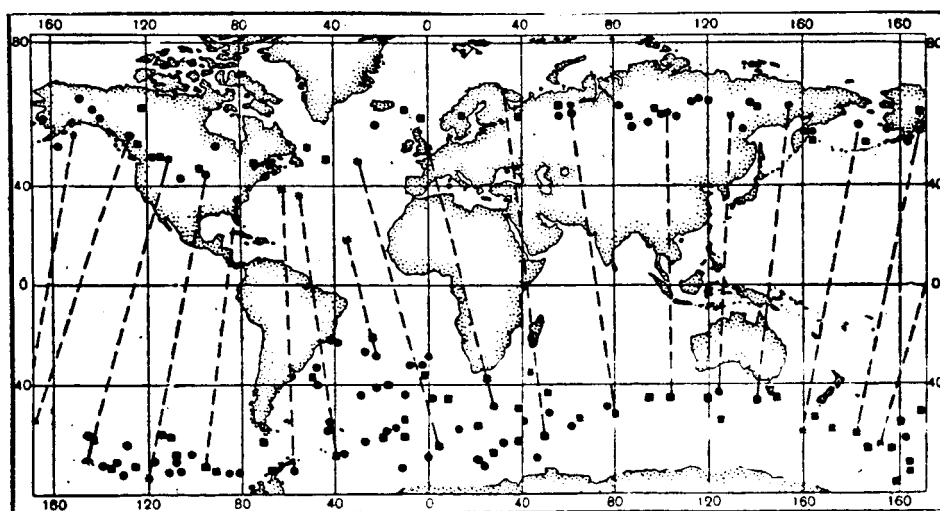


Fig.1. Distribution of radiation intensity in the radiation belts according to data of the 2nd and 3rd spaceships-satellites. Circles refer to data of the 2nd spaceship, squares - those of the 3rd. Conjugated points are linked with the basic ones by dotted lines.

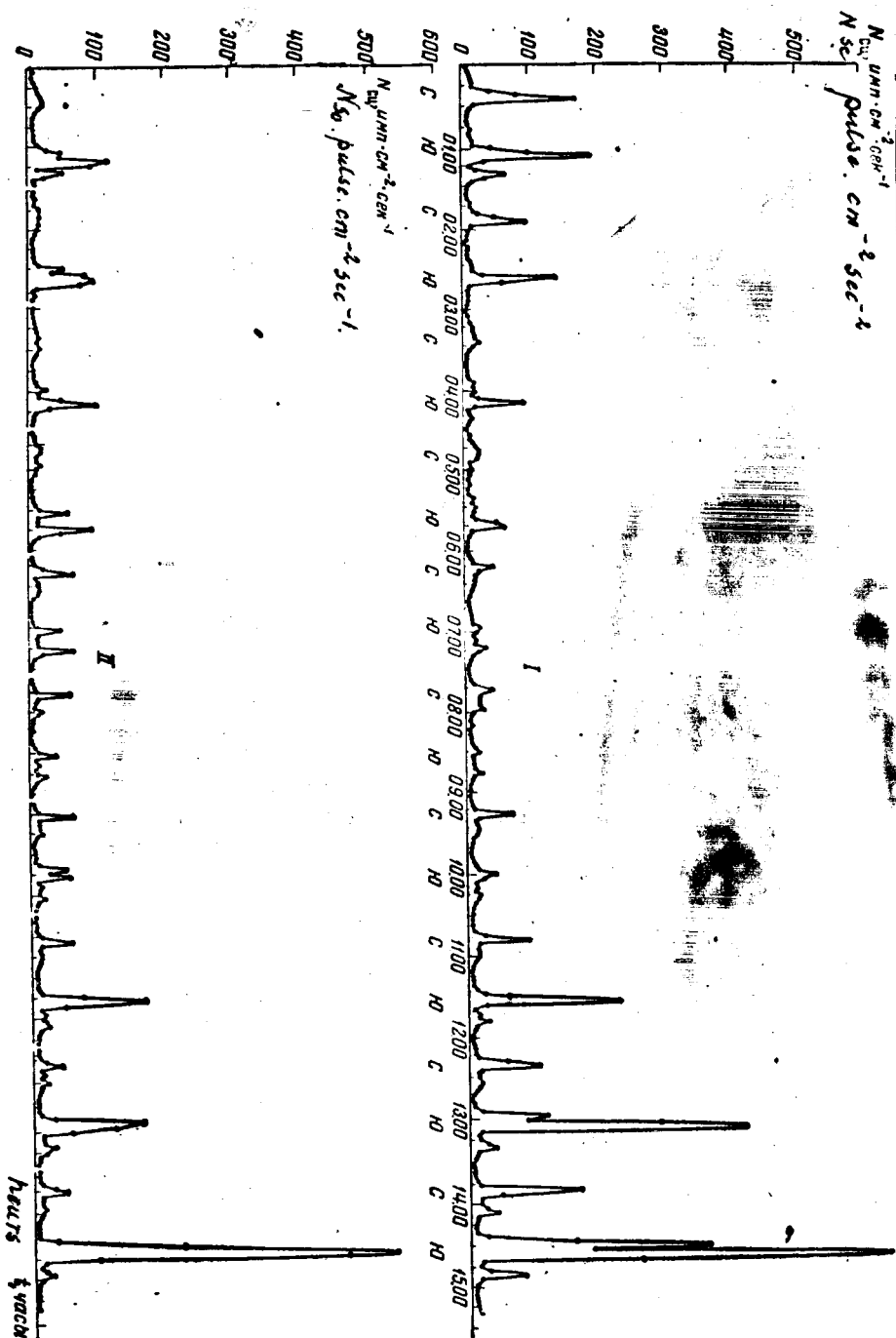


Fig. 2. Comparison of scintillation counter readings on the 2nd and 3rd
spacehips-satellites.

Curve I -- measurements on the 2nd spaceship; II - measurements on the 3rd
spaceship-satellite.

In Fig.3 the regions of increased intensity that cannot be explained by the latitude effect of cosmic rays, are outlined by dash-dotted line and shaded. On the map of Fig.4 drawn are the lines of equal intensity obtained by way of finding the coordinates of the intersection point of the experimental curve (Fig.2, lower curve) with the lines corresponding to intensity levels 5, 15, 30, 100, 200 and 400 pulse $\text{cm}^{-2}\text{sec}^{-1}$. When comparing with the data obtained aboard the 2nd spaceship-satellite, a slight narrowing of the outer belt band is observed in both hemispheres. The relative decrease in brehmstrahlung intensity in the outer belt vs data of the 2nd spaceship-satellite is characterized in Table 1.

T A B L E 1

Geographical region	Ratio of brehmastrahlung intensities by measurements on the 2nd and 3rd spaceships-sat.	Geographical region	Ratio of brehmastrahlung intensities by measurements on the 2nd and 3rd spaceships-sat.
No.America	1.7	South Pacific	1.1
Siberia	8.5	Australia	1.0
Europe and NorthAtlant.	3.5	South Atlant.	0.6
Indian Ocean	1.4		

It may be seen from Table 1 that the radiation intensity in the outer belt has hardly diminished (it even increased in the South Atlantic)

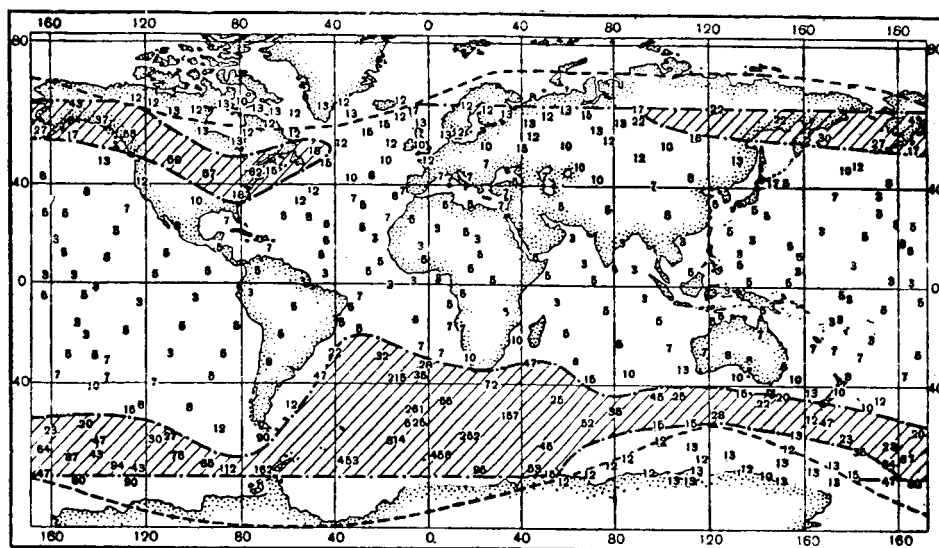


Fig. 3. Distribution of radiation intensity according to measurements aboard the 3rd spaceship-satellite.

The numbers indicate the intensity registered by the scintillation counter (in pulse $\text{cm}^{-2}\text{sec}^{-1}$). The dash-dotted line and shadings indicate the regions characterized by contribution from radiation belts. Dashed lines indicate the isochasms, or lines of maximum recurrence of aurorae.

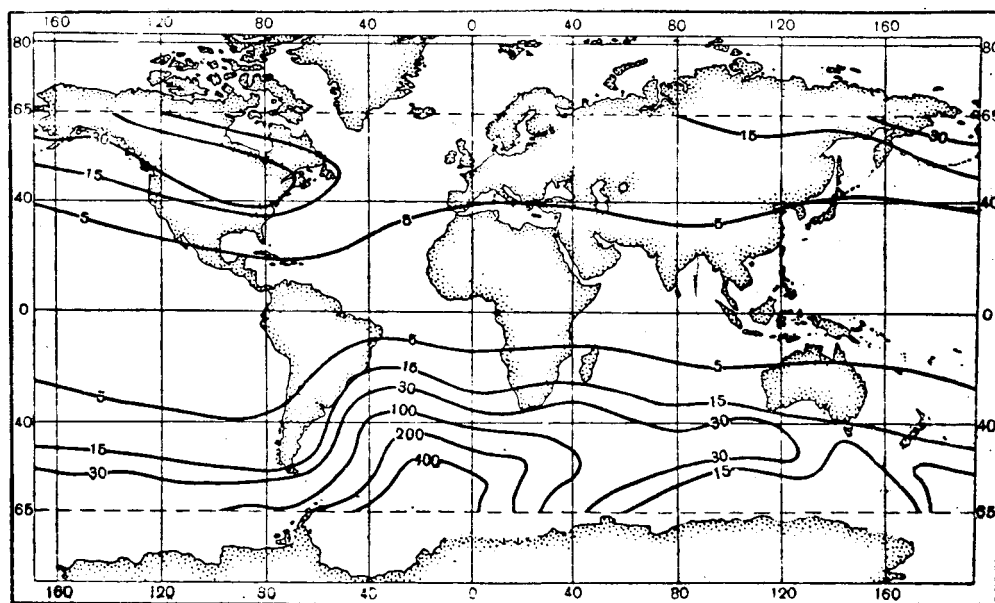


Fig. 4. Distribution of radiation intensity in radiation belts according to measurements aboard the 3rd spaceship-satellite.

The number over the lines indicate the intensity registered by the scintillation counter expressed in pulse $\cdot \text{cm}^{-2}\text{sec}^{-1}$.

while in the Northern hemisphere one may observe an intensity decrease from 1.7 to 8.5 times. It must be noted, that the flight of the 2nd spaceship-satellite took place under moderate storm conditions, and that of the 3rd spaceship - immediately after a rather intense ($K = 8$) magnetic storm [3, 4]. That is why the altitude course of intensity, obtained by way of direct comparison of data from Table 1 is possibly distorted. However, taking advantage of the fact that the orbit of 3rd spaceship is more eccentric than that of the 2nd spaceship-satellite, which is close to circular, one may determine the altitude course of radiation intensity in the 185 - 235 km altitude range by measurements on the 3rd spaceship, assuming that this course is identical in both hemispheres. At the same time, the data obtained by measurements aboard the 2nd spaceship-satellite will be utilized for the purpose of rate setting. If we take for radiation intensity measure the height of the peaks in Fig.2 (after subtracting the cosmic "background"), the following data are obtained:

The radiation intensity of the outer belt in the Southern hemisphere, as measured aboard the 2nd spaceship-satellite (at 330 km mean altitude) was as an average 2.2 times higher than that in the Northern hemisphere (mean altitude 320 km). The same ratio computed according to measurements aboard the 3rd spaceship-satellite (the mean altitude of the belt was 235 km in the Southern hemisphere, and 185 km in the Northern hemisphere) was 4.4. Hence one may conclude, that the radiation intensity decreases two times in the outer belt at passing from 235 km to 185 km altitude.

Contrary to the above-considered radiation belt areas, the region of increased intensity in the South Atlantic underwent more complex variations with height. Circles in the map of Fig.5 indicate a series of points obtained during spaceship's flight through that region. The pickup readings at these points are compiled in Table 2 and one of the flight's convolutions is graphically described on Fig.6. The point numbering on the map, on the graph and in the Table is identical. Plotted also on the map are curves of equal brehmstrahlung intensity obtained during counting rate measurements by the scintillation counter (the numbers over the lines are intensities expressed in pulse $\text{cm}^{-2}\text{sec}^{-1}$).

The spatial position of the South Atlantic region of increased radiation has varied: If the "slit" between the inner and the outer belts was noticeable during measurements aboard the 2nd spaceship, for example points 11, 12, 13, 14 in Fig.1 of reference [5], at which the brehmstrahlung intensity acquired values of 154, 344, 178 and 608 pulse $\text{cm}^{-2}\text{sec}^{-1}$ respectively), this brehmstrahlung intensity reached at the analogous convolution of the 3rd spaceship-satellite (points 14, 15, 16 and 17 in Fig.5) a maximum in the "slit" region (32, 215, 530 and 458 pulse $\text{cm}^{-2}\text{sec}^{-1}$ respectively). Besides, all the South Atlantic region of increased intensity notably shifted as a whole toward the northwest by comparison with the position determined aboard the 2nd spaceship-satellite. It is possible that such displacement and also the fact that at altitude decrease by 100 km the brehmstrahlung intensity

in that region not only decreased but even somewhat increased (see Tab.1) is the consequence of the magnetic storm of 30 Nov- 1 Dec.1960. But it is also quite possible that we met here with some entirely new phenomenon taking place at the inner boundary of the radiation belts.

The estimate of energy of brehmstrahlung γ -quanta from outer belt electrons at averaging by all the points where this belt is observed, gives the quantity $E_\gamma \approx 2 \cdot 10^5$ eV. At reasonable assumption concerning the mean energy of electrons inducing this brehmstrahlung (for example $E_e \approx 3 \cdot 10^5$ eV), one may estimate the electron fluxes in the outer belt at these heights. Thus, to the intensity level of 400 pulse \cdot cm $^{-2}$ sec $^{-1}$ corresponds an electron flux of $2 \cdot 10$ part. cm $^{-2}$ sec $^{-1}$.

The further comparison with the results obtained during measurements on the second spaceship-satellite, provides evidence that the intensit of the proton component decreased significantly. If earlier proton radiation was observed at least at eight points of the flight trajectory (in Fig.5 these points are indicated by dark circles), now it will only contribute

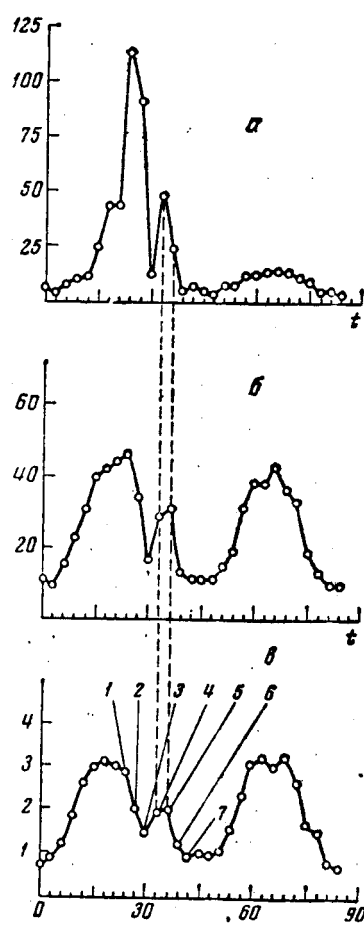
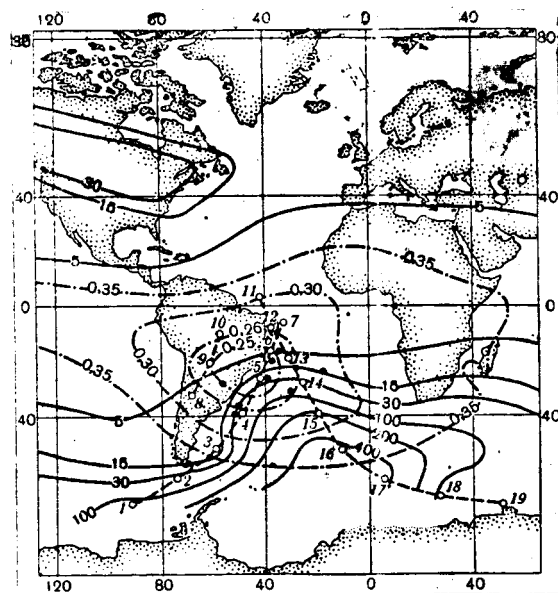


Fig.5 Readings of the gas-discharge and sc. counters over one of the portions of traj. a - intensity by sc.c reading b - energy liber. in crystal g - intensity by gas-d-ct. r. The numbers correspond to points in Table 2 (1 - 7).

notably at points 4 and 5 (see Fig. 5 and 6). Indeed, the intensity of charged particles registered at these points by the gas-discharge counter constitutes respectively 0.72 and 0.92 pulse $\text{cm}^{-2}\text{sec}^{-1}$ (after subtracting the cosmic background). The maximum contribution from the registration of brehmstrahlung in that detector cannot exceed 0.35 pulse $\text{cm}^{-2}\text{sec}^{-1}$ for point 4 and 0.15 pulse $\text{cm}^{-2}\text{sec}^{-1}$ for point 5, for the efficiency of brehmstrahlung registration by the gas-discharge counter does not exceed 1%, and the brehmstrahlung intensity at points 4 and 5 (minus the cosmic background) according to scintillation counter data is respectively 35 and 15 pulse $\text{cm}^{-2}\text{sec}^{-1}$. In reality, the indicated efficiency is as an average equal to $0.3 \pm 0.1\%$ for all cases of outer belt's observations, and the contribution of brehmstrahlung to gas-discharge counter readings is less than the considered one.

Thus, the count intensity of the gas-discharge counter at points 4 and 5 cannot be explained by the registration of brehmstrahlung. Besides, the counting rate of the scintillation counter drops more than twice at transition from point 4 to point 5, while the energy liberation in the crystal and the counting rate of the gas-discharge counter



(curves 2 and 3 of Fig. 6) increase. This indicates that by comparison with point 4, the share of charged particles in the total content of radiation registered at the point 5 increases significantly as that of brehmstrahlung decreases.

TABLE 2

PICKUP READINGS OF THE RADIOMETRIC APPARATUS ABOARD THE 3rd SPACESHIP
IN THE SOUTH ATLANTIC REGION

Number in Fig. 5	Intensity measured by the scint. counter in pulse $\text{cm}^{-2}\text{sec}^{-1}$	Energy liberation in the crystal $\text{MeV cm}^{-2}\text{sec}^{-1}$	Intensity measured by the gas-discharge counter, in pulse cm^{-2} sec^{-1}
	N_{sc}	sc	N_{G}
1	112		
2	90		
3	41, 16,9		
4	46, 28,2		
5	21, 30,1		
6	11,3		
7	11,3		
8	11,2		
9	13,1		
10	9,4		
11	9,4		
12	9,4		
13	15,0		
14	33,7		
15	71,5		
16	127,8		
17	131,6		
18	52,6		
19	39,5		

This is interesting to note because point 5 is situated at the center of the Brazilian magnetic anomaly, thus in the region where the greatest number of proton observations were carried out on the 2nd spaceship-satellite, and point 4 is at the edge of that region, as are all the remaining points where observations were conducted.

Inasmuch as it is difficult to assume the existence of high energy electrons ($E_e > 5$ MeV), which might penetrate directly inside the spaceship and cause the corresponding counts, it is most probable that the radiation registered at points 4 and 5 originates from protons of the inner radiation belt.

In the regions near these points the counting rate of the Geiger counter of the 2nd spaceship-satellite corresponded to an intensity near $10 \text{ particle} \cdot \text{cm}^{-2} \text{ sec}^{-1}$, while according to current measurements it decreased to $2 \text{ particle} \cdot \text{cm}^{-2} \text{ sec}^{-1}$; thus, at passing from 320 km to 220 km the intensity of proton radiation (taking into account the cosmic background at the given latitude) decreased by almost one order.

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***** THE END *****

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26 September 1962

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[N. B. - A certain amount of material published since then in the new periodical "Geomagnetizm i Aeronomiya" is not referred to here. See NASA TT F-8127, 8165, 8190 etc...]

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